



US008854259B2

(12) **United States Patent**  
**van Diggelen et al.**

(10) **Patent No.:** **US 8,854,259 B2**  
(45) **Date of Patent:** **\*Oct. 7, 2014**

(54) **METHOD AND SYSTEM FOR MAINTAINING A GNSS RECEIVER IN A HOT-START STATE**

(75) Inventors: **Frank van Diggelen**, San Jose, CA (US); **Charles Abraham**, Los Gatos, CA (US)

(73) Assignee: **Broadcom Corporation**, Irvine, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/619,571**

(22) Filed: **Sep. 14, 2012**

(65) **Prior Publication Data**

US 2013/0009811 A1 Jan. 10, 2013

**Related U.S. Application Data**

(63) Continuation of application No. 13/102,979, filed on May 6, 2011, now Pat. No. 8,310,393, which is a continuation of application No. 12/270,759, filed on Nov. 13, 2008, now Pat. No. 7,948,434.

(51) **Int. Cl.**  
**G01S 19/42** (2010.01)  
**G01S 19/31** (2010.01)  
**G01S 19/34** (2010.01)

(52) **U.S. Cl.**  
CPC ..... **G01S 19/34** (2013.01)  
USPC ..... **342/357.25**; 342/357.71; 342/357.74

(58) **Field of Classification Search**  
CPC ..... G01S 5/0263; G01S 19/24; G01S 19/34; G01S 19/42  
USPC ..... 342/357.25, 357.63, 357.71, 357.74; 701/468

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,511,205 A 4/1996 Kannan et al.  
5,592,173 A 1/1997 Lau et al.  
7,148,844 B2\* 12/2006 Salkhi ..... 342/357.62

(Continued)

FOREIGN PATENT DOCUMENTS

TW 200710424 A 8/2008

OTHER PUBLICATIONS

EPO Communication dated Jun. 22, 2011 in Application No. 09013963-5-220 / 2187228 (four pages).

(Continued)

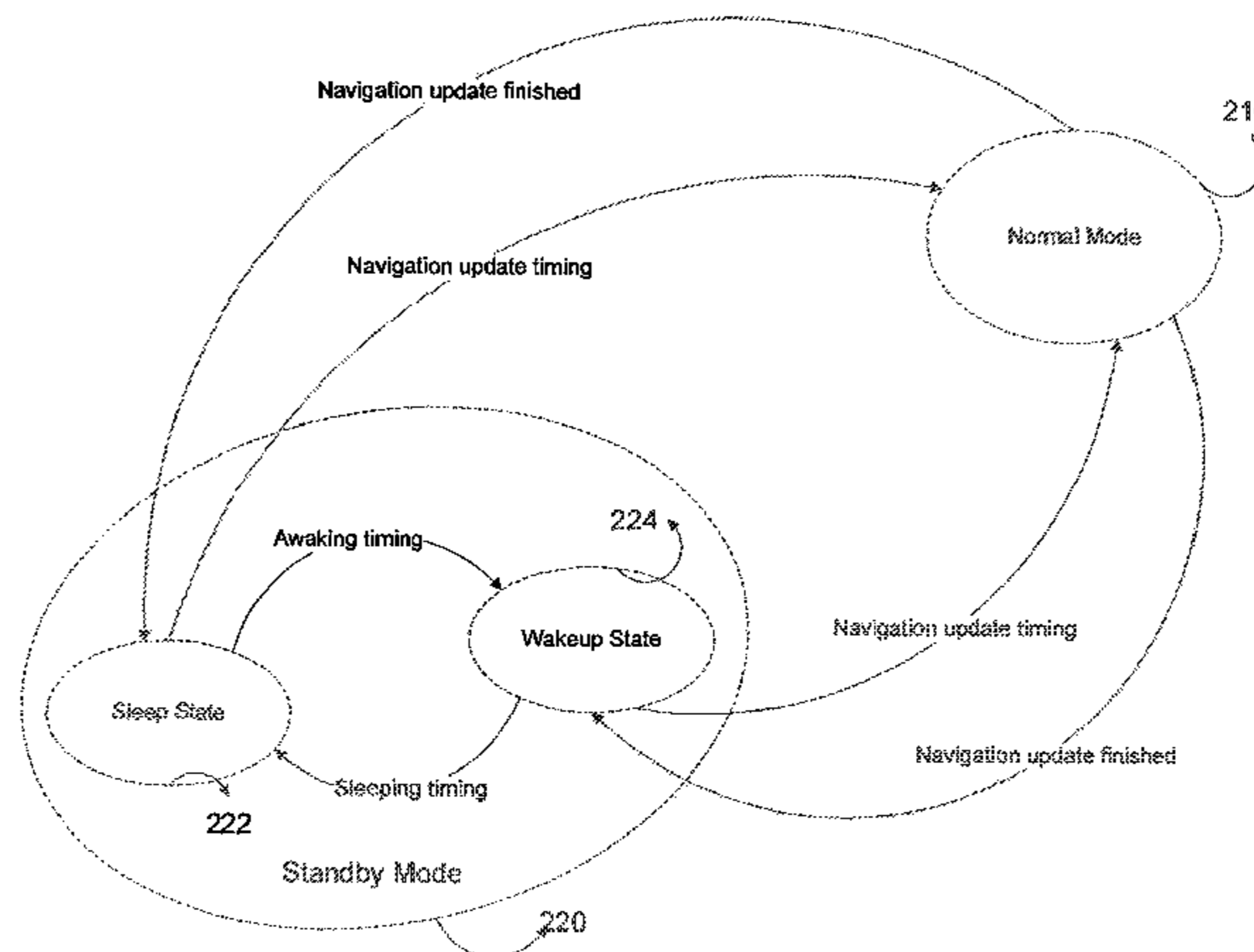
*Primary Examiner* — Dao Phan

(74) *Attorney, Agent, or Firm* — Sterne, Kessler, Goldstein & Fox P.L.L.C.

(57) **ABSTRACT**

A GNSS receiver in a wake up state during a standby mode may acquire ephemeris from received GNSS signals such as GPS signals and/or GLONASS signals. When subsequently transitioning from the standby mode to a normal mode operating at a high frequency clock, the acquired ephemeris may be utilized to generate a navigation solution for the GNSS receiver. The GNSS receiver in the wake up state during the standby mode may be switched to operate at the high frequency clock in order to receive GNSS signals. The GNSS receiver may extract complete ephemeris from the received GNSS signals, and may subsequently transition from the wake up state to a sleep state during the standby mode to save power. Radio frequency front-end components of the GNSS receiver may only be turned on to receive the GNSS signals. The GNSS receiver may transition between the standby mode and the normal mode.

**20 Claims, 4 Drawing Sheets**



(56)

**References Cited**

U.S. PATENT DOCUMENTS

7,414,921 B2 8/2008 Gauthey et al.  
7,948,434 B2 5/2011 Van Diggelen et al.  
8,310,393 B2 \* 11/2012 van Diggelen et al. .. 342/357.25  
2006/0149984 A1 7/2006 Yasumoto  
2007/0152878 A1 7/2007 Wang et al.  
2007/0159391 A1 7/2007 Kuo et al.  
2008/0098246 A1 4/2008 Kim

2008/0117100 A1 5/2008 Wang et al.  
2008/0117103 A1 5/2008 Wang et al.  
2008/0198069 A1 8/2008 Gronemeyer

OTHER PUBLICATIONS

European Search Report for European Patent Application No. 09013963.5-2220, dated Mar. 1, 2010.  
Office Action for related Taiwanese Patent Application No. 098138561, mailed Apr. 18, 2013; 5 pages.

\* cited by examiner

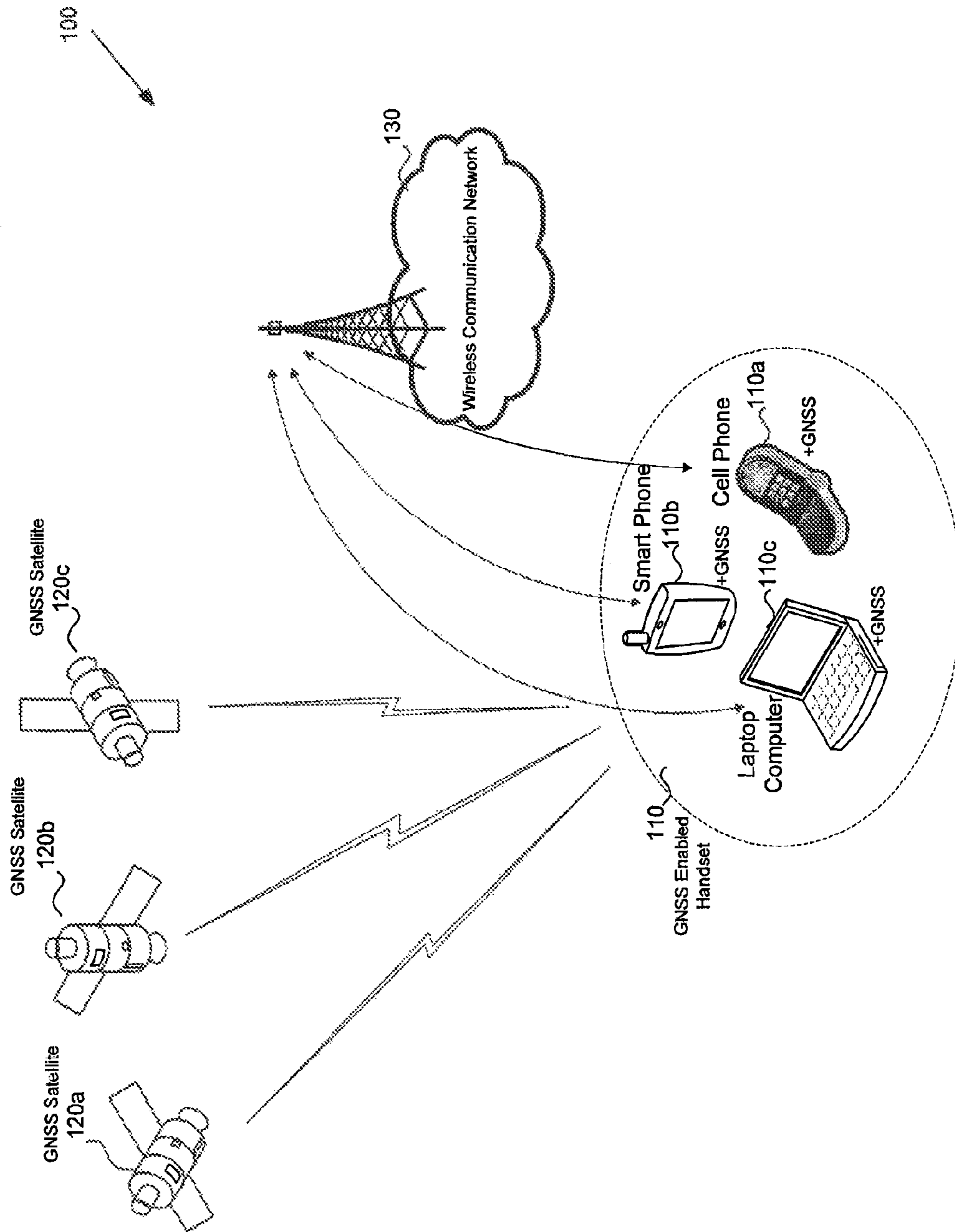


FIG. 1

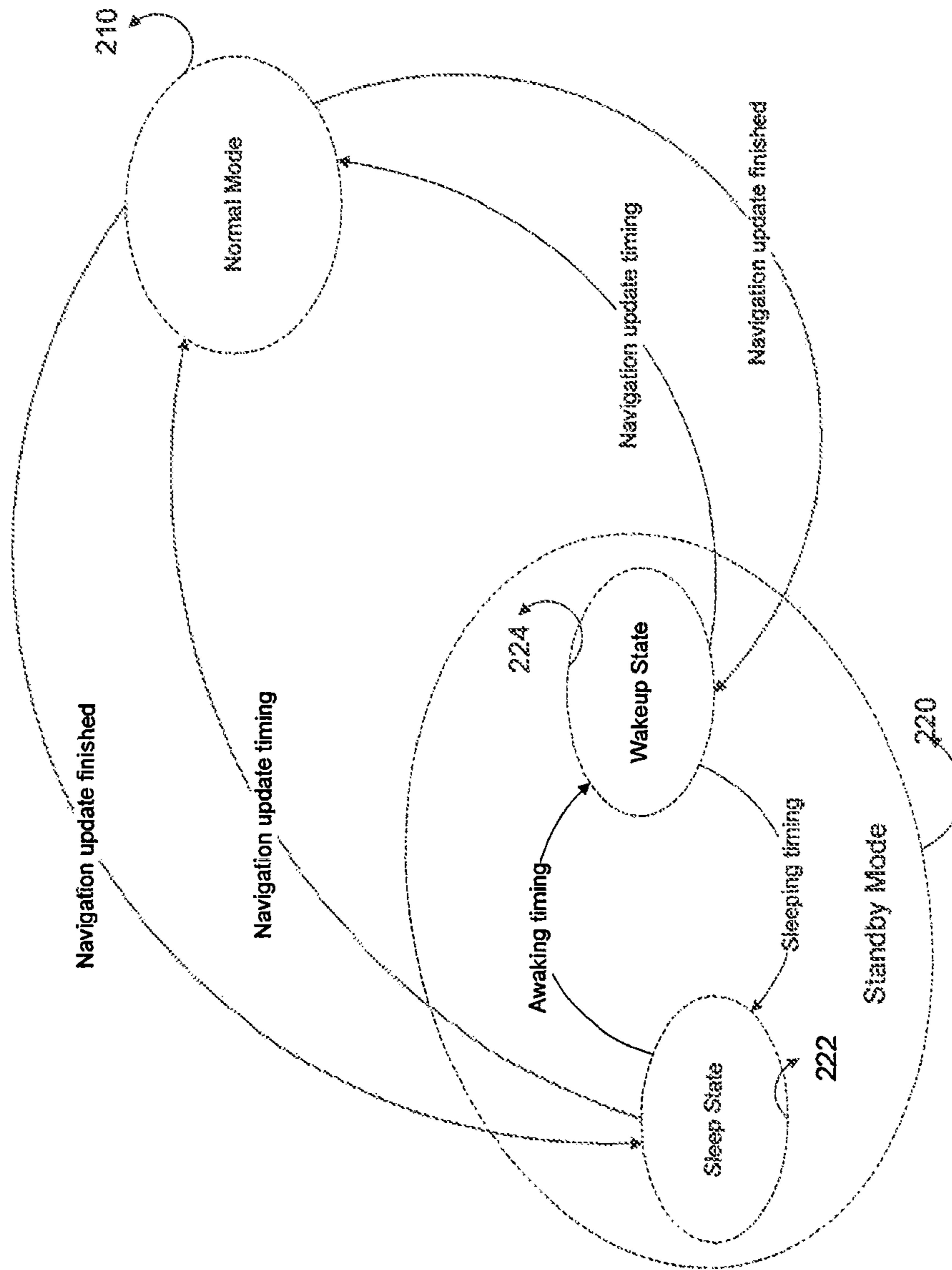


FIG. 2

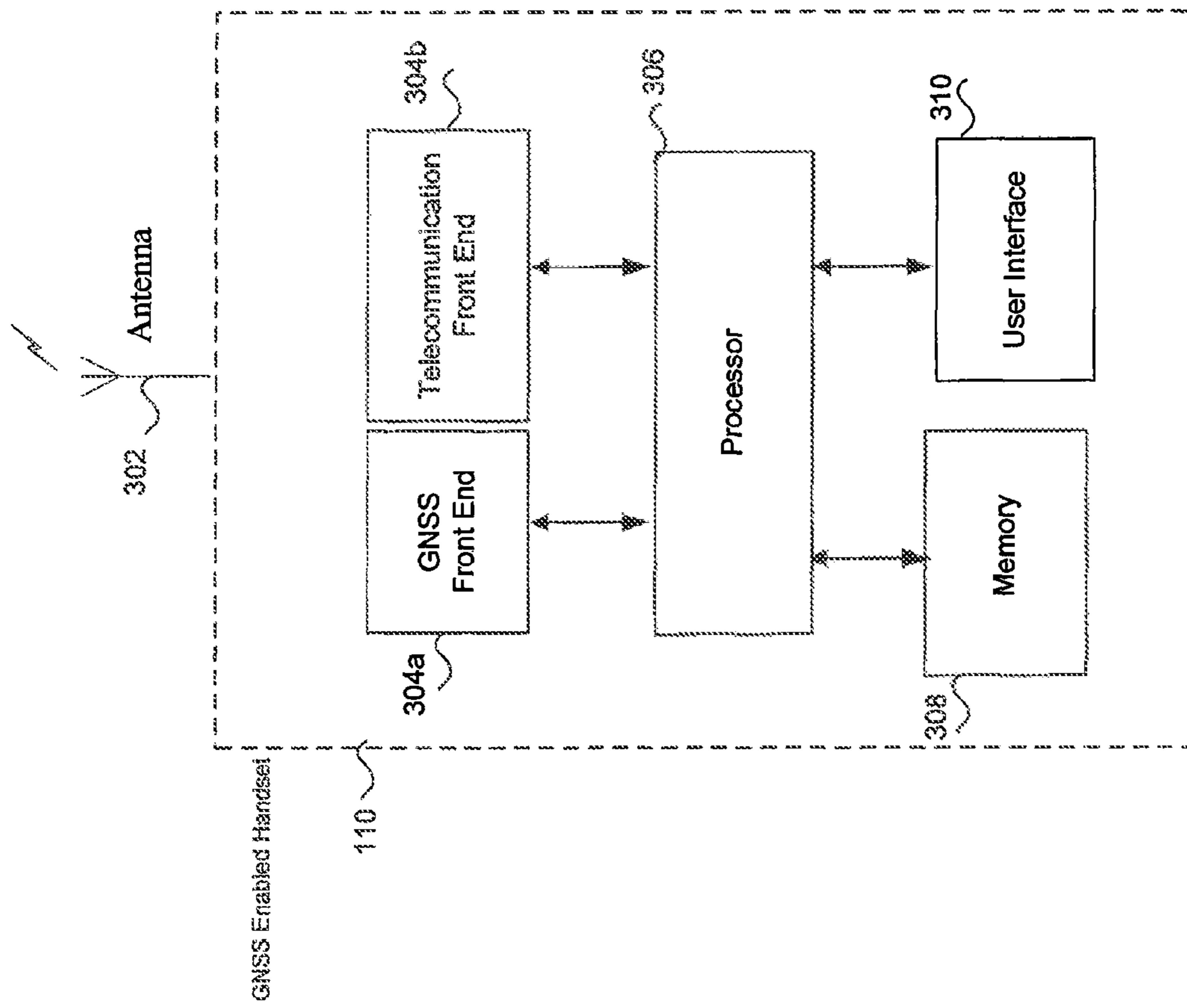


FIG. 3



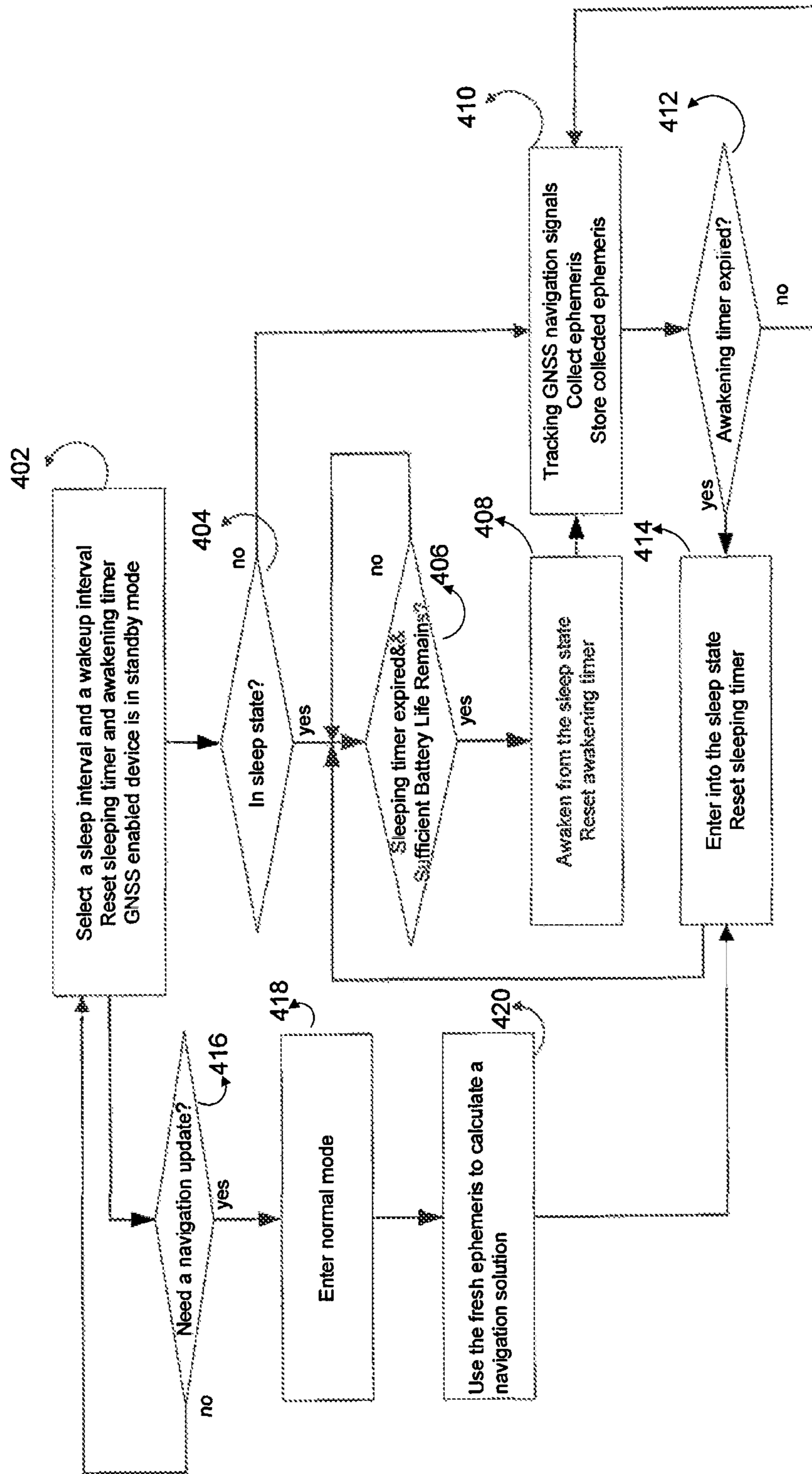


FIG. 4

**1****METHOD AND SYSTEM FOR MAINTAINING  
A GNSS RECEIVER IN A HOT-START STATE****CROSS-REFERENCE TO RELATED  
APPLICATIONS INCORPORATION BY  
REFERENCE**

This application is a continuation of U.S. application Ser. No. 13/102,979, filed on May 6, 2011, which is a continuation of U.S. application Ser. No. 12/270,759, filed on Nov. 13, 2008, now U.S. Pat. No. 7,948,434, issued on May 24, 2011, both of which are incorporated herein by reference in their entirety.

**FIELD OF THE INVENTION**

Certain embodiments of the invention relate to signal processing for communication systems. More specifically, certain embodiments of the invention relate to a method and system for maintaining a GNSS receiver in a hot-start state.

**BACKGROUND OF THE INVENTION**

A Global Navigation Satellite System (GNSS) such as the Global Positioning System (GPS) comprises a collection of twenty-four earth-orbiting satellites. Each of the GPS satellites travels in a precise orbit about 11,000 miles above the earth's surface. A GPS receiver locks onto at least three of the satellites to determine its position fix. Each satellite transmits a signal, which is modulated with a unique pseudo-noise (PN) code, at the same frequency. The GPS receiver receives a signal that is a mixture of the transmissions of the satellites that are visible to the receiver. The GPS receiver detects the transmission of a particular satellite based on corresponding PN code. For example, by correlating the received signal with shifted versions of the PN code for that satellite in order to identify the source satellite for the received signal and achieve synchronization with subsequent transmissions from the identified satellite.

When the GPS receiver is powered up, it steps through a sequence of states until it can initially determine a navigation solution comprising position, velocity and time. Afterwards, the satellite signals are tracked continuously and the position is calculated periodically. Precise orbital information, known as ephemeris or ephemeris data, transmitted by each satellite is used in calculating the navigation solution. Ephemeris or ephemeris data for a particular satellite may be decoded from orbit data once the GPS signal has been acquired. Each satellite broadcasts its own ephemeris data, the broadcast lasts for 18 seconds, repeating every 30 seconds.

Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

**BRIEF SUMMARY OF THE INVENTION**

A method and/or system for maintaining a GNSS receiver in a hot-start state, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

**2****BRIEF DESCRIPTION OF SEVERAL VIEWS OF  
THE DRAWINGS**

FIG. 1 is a diagram illustrating an exemplary GNSS satellite navigation system operable to maintain a GNSS receiver in a hot-start state, in accordance with an embodiment of the invention.

FIG. 2 is a state diagram illustrating an exemplary GNSS receiver operation that enables the GNSS receiver to be maintained in a hot-start state, in accordance with an embodiment of the invention.

FIG. 3 is a diagram illustrating an exemplary GNSS enabled device comprising a GNSS receiver operable to be maintained in a hot-start state, in accordance with an embodiment of the invention.

FIG. 4 is a flow chart illustrating exemplary steps for maintaining a GNSS receiver in a hot-start state, in accordance with an embodiment of the invention.

**DETAILED DESCRIPTION OF THE INVENTION**

Certain embodiments of the invention may be found in a method and system for maintaining a GNSS receiver in a hot-start state. Various aspects of the invention may enable a GNSS enabled handset to operate in a normal mode and a standby mode. In the standby mode, the GNSS enabled handset may be configured to switch periodically or aperiodically between a sleep state in the standby mode and a wakeup state in the standby mode. For example, the GNSS enabled handset in the standby mode may be configured to transition from the sleep state in the standby mode to the wakeup state in the standby mode. In the wakeup state of the standby mode, the GNSS enabled handset may enable turning on corresponding GNSS front end to track satellite signals and acquire fresh navigation information such as fresh ephemeris from the satellite signals. The acquired fresh ephemeris may be stored and may be used for future start-ups of the GNSS enabled handset to generate a navigation solution in the normal mode. The satellites signals may comprise GPS signals, GALILEO signals, and/or GLONASS signals. The GNSS enabled handset may operate in various ways. For example, after the start-up for various operations in the normal mode, the GNSS enabled handset may be configured to return to either the sleep state or the wakeup state from the normal mode, or just stay in the normal mode. A sleep period of the sleep state and a wakeup period of the wakeup state may be predetermined or may be dynamically adjusted. The sleep period and the wakeup period may be determined based on QoS, quality of satellite signals, and/or user inputs. To generate a navigation solution for the GNSS enabled handset, the fresh ephemeris may be acquired after the GNSS enabled handset transitions from the sleep state in the standby mode to the wakeup state in the standby mode, and may be utilized. Accordingly, the sleep period may be chosen such that it is less than a period at which the fresh ephemeris is changed by one or more satellites, and the wakeup period may be chosen so that it is long enough to enable collection of the fresh ephemeris.

FIG. 1 is a diagram illustrating an exemplary GNSS satellite navigation system operable to maintain a GNSS receiver in a hot-start state, in accordance with an embodiment of the invention. Referring to FIG. 1, there is shown a GNSS satellite navigation system **100**, comprising a GNSS enabled handset **110**, of which a GNSS enabled cell phone **140a**, a GNSS enabled smartphone **140b**, and a GNSS enabled laptop **140c** are presented, a plurality of GNSS satellites **120a-120c**, and a wireless communication network **130**.



The GNSS enabled handset **110** may comprise suitable logic circuitry and/or code that may be to receive satellite broadcast signals from the GNSS satellites **120a-120c** to determine a position fix of the GNSS enabled handset **110**. The GNSS enabled handset **110** may be capable of transmitting and/or receiving radio signals via the wireless communication network **130**, which may be compliant with, for example, 3GPP, 3GPP2, WiFi, and/or WiMAX communication standards. The GNSS enabled handset **110** may support various operating modes such as, for example, a normal mode (high power) and a standby mode (lower power), to accomplish different tasks during the process of acquiring and maintaining the GNSS information.

The normal mode may comprise a mode in which the GNSS enabled handset **110** operates at its normal current consumption level to support its main system CPU to run all main functions normally. In the normal mode, the GNSS enabled handset **110** may utilize a high speed clock that consumer more power than a low speed clock that may be utilized for the standby mode.

The standby mode may comprise a mode in which the GNSS enabled handset **110** operates at it's a low current consumption level. For example, in the standby mode, the GNSS enabled handset **110** may operate at a low-power level to monitor and activate bus activity. In the standby mode, the GNSS enabled handset **110** may be configured to turn off main functions that depend on its main system CPU. In this regard, the GNSS enabled handset **110** in the standby mode may utilize a low frequency clock rather than a high frequency clock that is utilized in the normal mode.

In the standby mode, the GNSS enable handset **110** turns off corresponding radio components required for transmitting and/or receiving data via the wireless communication network **130**. However, the GNSS enabled handset **110** may be configured to turn on or off radio components related to receiving GNSS data as needed. The GNSS enabled handset **110** in the standby mode may be in a wakeup state or a sleep state. The wakeup state in the standby mode corresponds to the situation that the GNSS enabled handset **110** is in the standby mode and is capable of receiving GNSS data. The sleep state in the standby mode corresponds to the situation where the GNSS enabled handset **110** is in the standby mode and is not capable if receiving GNSS data.

Depending on the knowledge of the GNSS information such as last GNSS position, current GNSS time and/or ephemeris data, the GNSS enabled handset **110** may apply different strategies for GNSS start-up, for example, a cold-start, a warm-start, or a hot-start, in acquiring GNSS information. In this regard, in a standby mode, the GNSS enabled handset **110** may be configured to maintain the GNSS information in a hot-start state by periodically waking up and running long enough to decode fresh ephemeris. The decoded fresh ephemeris may be used in subsequent startups to improve the time to first fix (TTFF) for the GNSS enabled handset **110**.

The GNSS satellites **120a-120c** may comprise suitable logic, circuitry and/or code that may be enabled to generate and broadcast suitable radio-frequency signals. The broadcast RF signals may comprise various navigation information such as orbital information, known as ephemeris or ephemeris data. The orbital information may comprise orbital location as a function of GNSS time. The broadcast ephemeris may change every two hours at the GNSS satellites **120a-120c** and may be valid for a particular period of time into the future, for example, four hours. The broadcast ephemeris may be received and decoded by a GNSS satellite receiver, which may be integrated in the GNSS enabled handset **110**. The

broadcast ephemeris may be utilized to determine a navigation solution such as, for example, position, velocity, and clock information of the GNSS enabled handset **110**.

The wireless communication network **130** may comprise suitable logic, circuitry and/or code that may be enabled to provide various voice and/or data services via CDMA 2000, WCDMA, GSM, UMTS, WiFi, or WiMAX communication standards.

In operation, the GNSS enabled handset **110** may be enabled to receive satellite broadcast signals from the GNSS satellites **120a-120c** to determine a navigation solution such as a position fix of the GNSS enabled handset **110**. A sequence of states may be executed to acquire and maintain the GNSS navigation information such as ephemeris in order to calculate the navigation solution for the GNSS enabled handset **110**. For example, in a standby mode, the GNSS enabled handset **110** may be enabled to maintain ephemeris in a hot-start state by periodically waking up to acquire GNSS broadcast signals from the GNSS satellites **120a-120c** and running long enough to decode ephemeris. The fresh ephemeris may be used in subsequent startups to improve the time to first fix (TTFF) of the GNSS enabled handset **110**. The determined navigation solution may be used for various location based services via the GNSS enabled handset **110** and/or the wireless communication network **130**.

FIG. **2** is a state diagram illustrating an exemplary GNSS receiver operation that enables the GNSS receiver to be maintained in a hot-start state, in accordance with an embodiment of the invention. Referring to FIG. **2**, there is shown an exemplary operation state machine comprising a normal mode **210** and a standby mode **220**. The standby mode **220** may comprise a sleep state **222** and a wakeup state **224**.

In the normal mode **210**, the GNSS enabled handset **110** may be fully powered to perform the functions of GNSS signal search, acquisition, measurement and satellite tracking. The period of a full operating cycle for the normal mode **210** may be software adjustable. The GNSS enabled handset **110** in the normal mode **210** may output position information at a user-defined rate. Depending on implementation, the GNSS enabled handset **110** may be configured to switch automatically between the standby mode **220** and the normal mode **210** to save power, or just stay in the normal mode after being switched from the standby mode. In the standby mode **220**, the GNSS enabled handset **110** may be operating at minimal power, which may be significantly less than in the normal mode **210**. In this regard, in the standby mode **220**, the GNSS enabled handset **110** may be configured in the sleep state **222** or in the wakeup state **224**. In the sleep state **222**, the GNSS enabled handset **110** may be configured to turn off GNSS RF components to save power consumption.

The GNSS enabled handset **110** may be configured to periodically wake up and enter the wakeup state **224** from the sleep state **222** to acquire fresh ephemeris with lower power consumption. The ephemeris may change every two hours at satellites such as the GNSS satellites **120a-120c**, and may be good for 4 hours. An appropriate wake up interval of, for example, every two hours, may be utilized. In the wakeup state **224**, the GNSS enabled handset **110** may acquire ephemeris and maintain GNSS navigation information without being fully powered. For example, the GNSS enabled handset **110** may wake up without even turning on user interface components such as the display. During the wakeup state **224**, the GNSS enabled handset **110** may stay on long enough to acquire a complete ephemeris. The GNSS enabled handset **110** may consume a small amount of battery power for various operations during the wakeup state **224**. The GNSS enabled handset **110** may store the acquired ephemeris data to



provide the fresh ephemeris for GNSS start-up to, for example, calculate a navigation solution or perform navigation update in the normal mode 210. The GNSS enabled handset 110 may return to the sleep state 222 or the wakeup state 224 in the standby mode 220 after the navigation update. Depending on implementation, the GNSS enabled handset 110 may stay in the normal mode after the navigation update. The period of a full sleep-wakeup cycle in the standby mode may be software adjustable via various timing control. For example, the GNSS enabled handset 110 may be configured via setting up a wakeup timer and/or a sleep timer for updating navigation information of the GNSS enabled handset 110. The wakeup timer and/or the sleep timer may be pre-determined and/or may be adjusted depending on, for example, required QoS and/or quality of the acquired ephemeris data.

FIG. 3 is a diagram illustrating an exemplary GNSS enabled device comprising a GNSS receiver operable to be maintained in a hot-start state, in accordance with an embodiment of the invention. Referring to FIG. 3, there is shown the GNSS enabled handset 110 comprising an antenna 302, a GNSS front end 304a, a telecommunication front end 304b, a processor 306, a memory 308, and a user interface 310.

The antenna 302 may comprise suitable logic, circuitry and/or code that may be enabled to receive L band signals from the plurality of GNSS satellites 120a-120c. The antenna 302 may be enable transmission and/or reception of radio signals via, for example, a 3G radio communication system, for communications among 3G devices.

The GNSS front end 304a may comprise suitable logic, circuitry and/or code that may be enabled to receive GNSS satellite broadcast signals via the antenna 302 and convert them to GNSS baseband signals for further baseband signal processing in the processor 306.

The front end 304b may comprise suitable logic, circuitry and/or code that may be enabled to transmit and/or receive radio frequency (RF) signals via a telecommunication network such as the wireless communication network 130 via the antenna 302. The front end 304b may enable conversion of the received RF signals to corresponding baseband signals, which may be suitable for further baseband signal processing in the processor 306.

The processor 306 may comprise suitable logic, circuitry and/or code that may be enabled to process received satellite signals as well as signals received from the wireless communication network 130. The processor 306 may be configured to extract navigational information from received satellite signals. The extracted navigation information may be utilized to determine navigational information such as a position fix for the GNSS enabled handset 110. The processor 306 may be programmed to turn on or off the GNSS front end 304a. For example, the processor 306 may periodically enter the standby mode 220 in which the GNSS front end 304a is turned on and information such as ephemeris from the GNSS satellites 120a-120c may be received. The processor 306 may enable the GNSS enabled handset 110 to operate by consuming a minimal amount of power during the wakeup state 224. For example, in the standby mode 220, the processor 306 may periodically wake up the GNSS front end 304a for receiving GNSS signals, extract, and store information such as ephemeris from the received GNSS signals without even turning on the display or other circuitry in the GNSS enabled handset 110 that is not required to enable receiving of the information. In instances when a navigation update may be required, for example, via the user interface 310 or via various upper layer applications from the wireless communication network 130, the processor 306 may provide the fresh ephemeris stored in the memory 308 for use.

The memory 308 may comprise suitable logic, circuitry, and/or code that may enable storing of information such as executable instructions and data that may be utilized by the processor 306. The executable instructions may comprise algorithms that may be applied to extract ephemeris from received GNSS broadcast navigation signals and to calculate a navigation solution from the extracted ephemeris. The data may comprise GNSS navigation information such as the extracted fresh ephemeris. The memory 308 may comprise RAM, ROM, low latency nonvolatile memory such as flash memory and/or other suitable electronic data storage.

The user interface 310 may comprise suitable logic, circuitry, and/or code that may enable presentation of navigation information. The navigation information may be presented graphically, aurally, in response to user input requests for a navigation update via, for example, a keyboard, a keypad, a thumbwheel, a mouse, touchscreen, audio, a trackball and/or other input method.

In operation, a plurality of radio signals may be received at the antenna 302 coupled to the GNSS enabled handset 110. The received plurality of radio signals may be communicated to the GNSS front end 304a or the telecommunication front end 304b, respectively, depending on the type of received radio signals. When the GNSS enabled handset 110 may be in the standby mode 220, the processor 306 may be enabled to switch the GNSS enabled handset 110 between the sleep state 222 and the wakeup state 224 periodically to save power. The wakeup state 224 may allow the processor 306 to wake up the GNSS front end 304a for receiving GNSS signals and to acquire navigation information such as ephemeris from the GNSS satellites 120a-120c by using a small amount of power. In the wakeup state 224, the processor 306 may be enabled to extract complete ephemeris from the received GNSS signals, and store the extracted ephemeris in the memory 308, accordingly. Various operations such as, for example, acquiring fresh navigation information from the satellite signals in the wakeup state 224 may be executed without even turning on the user interface 310 to save power. When a navigation update may be needed, the processor 306 may use the latest ephemeris stored in the memory 308 to generate a navigation solution.

FIG. 4 is a flow chart illustrating exemplary steps for maintaining a GNSS receiver in a hot-start state, in accordance with an embodiment of the invention. Referring to FIG. 4, the exemplary steps start with the step 402. It is assumed that the GNSS enabled handset 110 may start in the standby mode 220. In step 402, the GNSS enabled handset 110 may select a sleep interval and a wake-up interval. The sleep interval and the wakeup interval may be predetermined or dynamically adjusted based on one or more factors comprising QoS, quality of the satellite signals, battery life, and user input. In addition, a sleep timer and a wakeup timer may be reset. The sleep timer and the wakeup timer may be used for timing control of the full sleep-wakeup cycle.

In step 404, it may be determined whether the GNSS enabled handset 110 may be in the sleep state 222. In instances where the GNSS enabled handset 110 may be in the sleep state 222, then, in step 406, it may be determined whether the sleep timer has expired and there may be sufficient battery life remained. In instances where the sleep timer may expire, then in step 408, the GNSS enabled handset 110 may wake up from the sleep state 224 and reset the awakening timer. In step 410, the GNSS enabled handset 110 may acquire GNSS navigation signals, acquire/decode a complete ephemeris from acquired GNSS navigation signals, and store the fresh ephemeris into the memory 308. In step 412, determine if the wake up timer has expired, in instances where the



wakeup timer may expire, then in step 414, the GNSS enabled handset 110 may enter into the sleep state 222 and reset the sleep timer, then return to the step 406. In step 404, in instances where the GNSS enabled handset 110 may not be in the sleep state 222, the next step is step 410.

In step 406, in instances where the sleep timer has not expired and/or there may be no sufficient battery life remained, and then execution remains in step 406. In step 412, in instances where the wakeup timer has not expired, then the next step is step 410. The GNSS enabled handset 110 may be switched from the standby mode 220 (step 402) to the normal mode 210 for a navigation update. In step 416, it may be determined whether a navigation update is requested. In instances where the GNSS enabled handset 110 may request navigation information, then in step 418, the GNSS enabled handset 110 may enter the normal mode 210. In step 420, the processor 306 may access the memory 308 for the fresh ephemeris to determine the requested navigation information. The GNSS enabled handset 110 may then enter the sleep state 222. Depending on implementation and/or QoS requirements, the GNSS enabled handset 110 may be configured to return to the wakeup state 224 in the standby mode from the normal mode 210, or stay in the normal mode 210 after performing the navigation solution.

Aspects of a method and system for maintaining a GNSS receiver in a hot-start state are provided. In accordance with various embodiments of the invention, a navigation satellite system receiver such as the GNSS enabled handset 110 may operate in the normal mode 210 and the standby mode 220. In the standby mode 220, the GNSS enabled handset 110 may be configured to switch periodically or aperiodically between the sleep state 222 and the wakeup state 224. For example, the GNSS enabled handset 110 in the standby mode 220 may be enabled to transition from the sleep state 222 in the standby mode 220 to the wakeup state 224 in the standby mode 220. In the wakeup state 224, the processor 306 may turn on the GNSS front end 304a to track satellite signals and acquire fresh navigation information such as fresh ephemeris from the satellite signals. The acquired fresh navigation information comprising fresh ephemeris may be stored in the memory 308 and may be used to provide for a start-up of the GNSS enabled handset 110. The GNSS enabled device 110 may utilize the fresh navigation information to generate a navigation solution in the normal mode 210. After acquiring fresh ephemeris in the standby mode 220, the GNSS enabled handset 110 may transition from the wakeup state 224 in the standby mode 220 back to the sleep state 222 in the standby mode 220. The satellite signals may be GPS signals, GALILEO signals, and/or GLONASS signals.

The GNSS enabled handset 110 may be implemented, such that after the start-up for various operations in the normal mode 210, the GNSS enabled handset 110 may be configured to return to either the sleep state 222 in the standby mode 220 or the wakeup state 224 in the standby mode 220, or just stay in the normal mode 210. A sleep period of the sleep state 222 in the standby mode 220 and a wakeup period of the wakeup state 224 in the standby mode 220 may be predetermined or may be dynamically adjusted. The sleep period in the standby mode 220 and the wakeup period in the standby mode 220 may be determined based on exemplary factors comprising QoS, quality of satellite signals, and/or user inputs. The sleep period in the standby mode 220 may be selected or chosen so that it is less than a period at which said fresh ephemeris is changed by one or more satellites. The wakeup period in the standby mode 220 may be selected so that it is long enough for a period required for collection of the fresh ephemeris.

Another embodiment of the invention may provide a machine and/or computer readable storage and/or medium, having stored thereon, a machine code and/or a computer program having at least one code section executable by a machine and/or a computer, thereby causing the machine and/or computer to perform the steps as described herein for maintaining a GNSS receiver in a hot-start state.

Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system, or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for satellite communication utilizing a navigation satellite system receiver, the method comprising:
  - acquiring ephemeris data;
  - adjusting a clock frequency at which the navigation satellite system receiver operates following the acquisition of the ephemeris data;
  - utilizing the acquired ephemeris data to generate a navigation solution for the navigation satellite system receiver while operating at the adjusted clock frequency, wherein the navigation satellite system receiver is configured to operate in a low-power mode, a moderate-power mode, and a high-power mode.
2. The method according to claim 1, wherein the navigation satellite system receiver operates in the high-power mode during the generation of the navigation solution.
3. The method according to claim 1, wherein the navigation satellite system receiver operates in the moderate-power mode during the acquisition of the ephemeris data.
4. The method according to claim 1, wherein, while operating in the low-power mode, the navigation satellite system receiver is configured to power off a component related to the acquisition of the ephemeris data.
5. The method according to claim 1, further comprising transitioning from the low-power mode to the moderate-power mode to acquire the ephemeris data.



9

6. The method according to claim 5, wherein the navigation satellite system receiver operates at a same clock frequency while operating in the low-power mode and the moderate-power mode.

7. The method according to claim 4, wherein the component related to the acquisition of the ephemeris data includes a satellite signal front-end unit.

8. The method according to claim 1, wherein the adjusting of the clock frequency comprises increasing the clock frequency at which the navigation satellite system receiver operates following the acquisition of the ephemeris data.

9. The method according to claim 1, wherein the clock frequency is a first clock frequency while the navigation satellite system receiver operates in the high-power mode, and is a second clock frequency while the navigation satellite system receiver operates in the low-power mode and the moderate-power mode.

10. The method according to claim 9, wherein the first clock frequency is greater than the second clock frequency.

11. A navigation satellite system receiver comprising:

a satellite signal front-end unit configured to acquire ephemeris data; and

a processor configured to:

generate a navigation solution for the navigation satellite system receiver based on the acquired ephemeris data, and

adjust a clock frequency at which the navigation satellite system receiver operates based on an operational mode of the navigation satellite system receiver, wherein the operational mode of the navigation satellite system receiver is selected from a low-power mode, a moderate-power mode, and a high-power mode.

12. The navigation satellite system receiver according to claim 11, wherein the navigation satellite system receiver operates in the high-power mode during the generation of the navigation solution.

13. The navigation satellite system receiver according to claim 11, wherein the navigation satellite system receiver operates in the moderate-power mode during the acquisition of the ephemeris data.

14. The navigation satellite system receiver according to claim 11, wherein the processor is configured to power off the satellite signal front-end unit during the low-power mode.

15. The navigation satellite system receiver according to claim 11, wherein the navigation satellite system receiver operates at a same clock frequency while operating in the low-power mode and the moderate-power mode, and operates

10

at a different clock frequency while operating at the high-power mode, wherein the different clock frequency is greater than the same clock frequency.

16. The navigation satellite system receiver according to claim 11, further comprising:

a user display to display the navigation solution, wherein the user display is powered off during the low-power mode and the moderate-power mode.

17. A method for satellite communication utilizing a navigation satellite system receiver, the method comprising:

transitioning from a low-power mode to a moderate-power mode;

acquiring ephemeris data following the transition to the moderate-power mode;

transitioning to a high-power mode;

generating a navigation solution for the navigation satellite system receiver utilizing the acquired ephemeris data following the transition to the high-power mode; and adjusting a clock frequency at which the navigation satellite system receiver operates during the transition to the high-power mode.

18. The method according to claim 17, wherein the clock frequency is a first clock frequency while the navigation satellite system receiver operates in the high-power mode and is a second clock frequency while the navigation satellite system receiver operates in the low-power mode and the moderate-power mode, and wherein the first clock frequency is greater than the second clock frequency.

19. A navigation satellite system receiver, comprising:

a satellite signal front-end unit configured to acquire ephemeris data, wherein the navigation satellite system receiver is configured to transition from operating in a low-power operational mode to an intermediate-power operational mode, and to operate in the intermediate-power operational mode during the acquisition of the ephemeris data; and

a processor configured to generate a navigation solution based on the acquired ephemeris data, wherein the navigation satellite system receiver is configured to operate in a high-power operational mode during the generation of the navigation solution.

20. The navigation satellite system receiver according to claim 19, wherein the processor is further configured to adjust a clock frequency at which the navigation satellite system receiver operates based on the operational mode of the navigation satellite system receiver.

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 8,854,259 B2  
APPLICATION NO. : 13/619571  
DATED : October 7, 2014  
INVENTOR(S) : van Diggelen et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title Page, Item (56), Foreign Patent Documents, TW 200710424 A, please replace "8/2008" with --3/2007--.

Signed and Sealed this  
Twenty-seventh Day of January, 2015



Michelle K. Lee  
*Deputy Director of the United States Patent and Trademark Office*